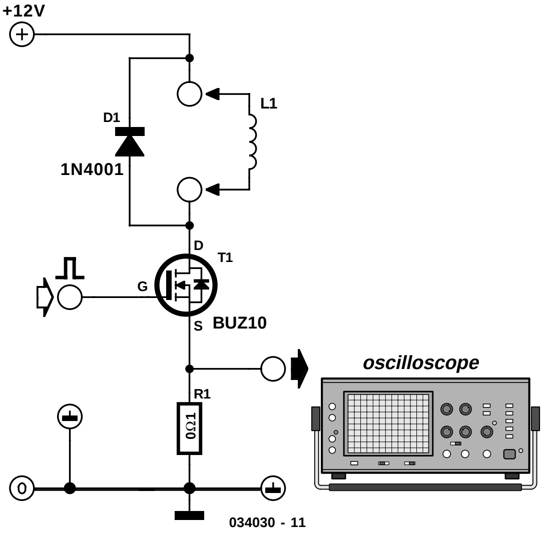
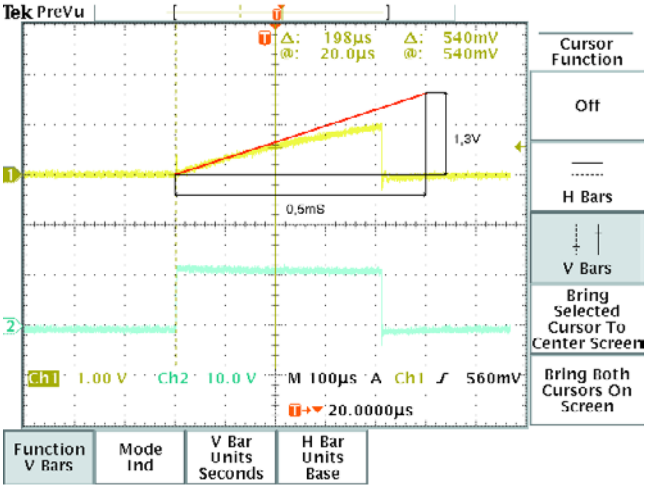
Low-cost Inductance Meter

033

1



2



P. Goossens

This inductance meter consists, all in all, of four components that can be mounted on a small piece of prototype board in a jiffy. In order to use this meter the following are also necessary: a power supply, a pulse generator and an oscilloscope. So this is not really a complete measuring instrument, but more of a handy tool for the hobby laboratory.

Inductors

An inductor does with current what a capacitor does with voltage, namely: store and release. A constant voltage across an ideal inductor causes a linearly increasing current. Or mathematically: $dI/dt = U/L$.

This formula may look a little strange, but it is actually very simple. dI/dt indicates how quickly the current changes in one second. U is the voltage across the inductor and L is the inductance (value) of the coil. From the above equation we can deduce that the larger the value of the coil, the slower will be the rate of increase of current.

The Circuit

If we apply a constant voltage for a short period of time across the inductor, we can determine the value of the coil by measuring how quickly the current increases. In our circuit (**Figure 1**), an external pulse generator provides a pulse, which drives the gate of FET T1. This causes the FET to conduct, which in turn causes the entire power supply voltage to be applied across the inductor. We make the assumption here that there is no current flowing in the inductor the moment the FET is switched on.

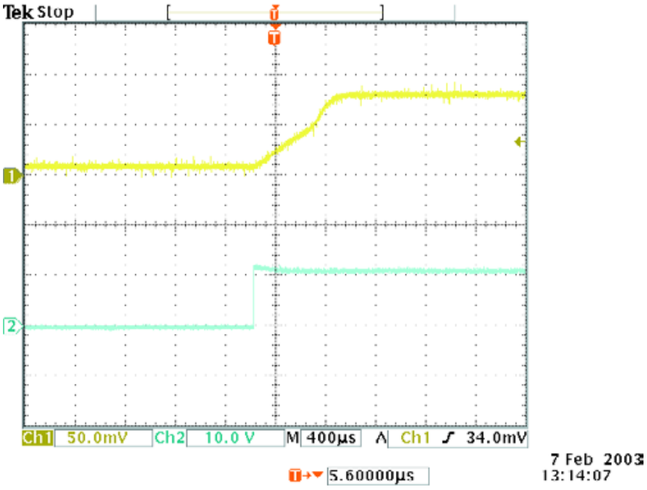
The voltage across this (unknown) coil results in an increasing current through it. This current flows via the FET through resistor R1. The current will cause a voltage drop across the resistor. If you examine this voltage with an oscilloscope, you will see that it increases linearly at first. The rate at which this occurs is a measure of the value of the inductor.

The instant the FET blocks, the inductor will continue to supply the current. That is because a negative voltage is required across the inductor for the current to fall. This is why a diode is connected in parallel with the inductor. The inductor will cause current to flow through the diode once the FET switches off. Because there is now a negative voltage across the inductor, the current in the coil will decrease. Without the diode, the coil would generate a very high voltage in an attempt to maintain constant current flow. The ignition coil in a car makes use of this property to generate a spark between the spark plug electrodes. But with electronics, sparks, smoke and fire are usually an indicator that something is wrong, hence the diode.

Calculating

If everything is correct, there will now be a nice picture on the oscilloscope. From this we should be able to calculate the value of the unknown coils, since that's what we were after in

3



the first place! The necessary calculations are fortunately very straightforward. As mentioned before, $\mathrm{d}I/\mathrm{d}t = U/L$. We also remember Ohm's Law, namely $U_R = I_R\, R$. Since the current through the resistor is equal to the current through the coil we may replace $\mathrm{d}I_L/\mathrm{d}t$ with $0.1\ \mathrm{d}U_R/\mathrm{d}t$. Also, the voltage across the coil (U_l) is known as 12 V. Substituting this in the first formula leads to: $0.1\ \mathrm{d}U_R/\mathrm{d}t = 12/L$. Finally, rearranging the terms gives: $L = 120/(\mathrm{d}U_R/\mathrm{d}t)$.

Example

An oscilloscope trace of a measurement of an unknown inductor is shown in **Figure 2**. The sloping line has been drawn in order to determine the increase of voltage per time unit. This line intersects the measurement at exactly the beginning of the measurement, since the rate of change is most accurate here.

As the picture shows, the voltage initially rises at a rate of 1.3 V/0.5 ms. This corresponds with a rate of change $\mathrm{d}U_R/\mathrm{d}t = 2600$ V/s. The inductance is therefore: $L = 120/2600 \approx 46$ mH.

In the example measurement you can see that the current does not increase linearly. This can be explained as follows: as soon as the current starts to increase, the voltage drop across T1 and R1 will also increase, reducing the effective voltage across L1. The rate of change of current is directly proportional to the voltage across the inductor. If the voltage across the inductor drops, then the rate of increase of current will also be smaller.

A second effect that can occur is when the graph curves upward. This can be clearly seen in the next measurement (refer **Figure 3**). This effect only occurs with inductors that have a core. Once the current increases to the point where the magnetic field causes the core to saturate, the core does not contribute to the magnetic field any further. From this point onwards, the inductance reduces with the consequence that the current will increase faster.

(034030-1)